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The relationship between genetic stability and variability in populations of rock grenadier in the North Atlantic

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V.V. Dushchenko

PINRO

Despite many years of experience in fishing the North Atlantic rock grenadier and in researching this species, many important aspects /34* of the rock grenadier's biology remain unstudied. These gaps in our knowledge, especially those that relate to matters of reproduction and migration, have so far made it impossible to determine the level of isolation of individual groupings of grenadier and to identify the source of recruitment for the stock in the Northwestern Atlantic. Attempts to utilize the polymorphic system of myogenic esterase

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*Translator's note: Numbers in the right-hand margin refer to the corresponding page in the Russian text.

[Nefedov et al., 1976] in order to identify isolated groupings of grenadier failed to give the expected results due to the insignificant /35
variability of gene and genotypic frequencies over the greater part of its geographic range. At the same time, variations in the concentration of phenotypes of esterase were found to depend on the sex and size of the fish, making it possible to advance a hypothesis regarding the selective nature of polymorphism at locus Est-1 [Alekseev et al., 1979] and the natural effect of the migration of grenadier eggs and larvae, carried by the ocean currents, on the formation of the gene pool of local populations [Dushenko, 1981]. One of the procedures that could be used to test these hypotheses might be an analysis of the destribution of genotypic frequencies by generations, but since an accurate determination of age is difficult in rock grenadier, an attempt has been made to follow the variability of esterase on the basis of five-centimeter size classes.

Samples of 200 to 300 specimens were utilized for the analysis; they were obtained from the chief fishing regions of the North Atlantic in 1979 and 1980, which, considering the slow growth rate of the rock grenadier after the age of 10, permitted comparison without the need to make adjustments for growth increment. The classification of esterase isoenzymes was made on the basis of a method described earlier [Duschenko, 1980]. The statistical treatment was contucted according to the method guidelines of TINRO [1980]. Size groups that contained less than ten fish of either sex were not utilized to compare samples.

First of all, it was possible to establish by analyzing the two sexes separately that the nature of variations in gene frequencies are

in the majority of cases identical, but with the difference that the corresponding peaks on the curve for females are situated one or two size classes to the right of those for males (Fig. 1). This corresponds well with available data on the growth rate of rock grenadier [Savvatimskii, 1975] and indicates a direct relationship between the phenomenon observed and the variability in different generations.

The determination of confidence intervals (Figure 2) and a comparison of gene frequencies by using the "t-criteria" showed differences between individual size classes with a probability of about 0.95 or more in all of the smaples analyzed. Highly credible differences were observed in a number of cases even between neighboring groups. A check on their stability showed that they can not be maintained over time. There was only one replication (samples 4 and 5, obtained after a one-month interval) in the material examined, but this example rather clearly illustrated the inconstancy of the variations that were observed in gene frequencies. It is true that the catches from which these samples were taken also differ (a) in the ratio of the sexes (in one of them males numbered more than 90 per cent, while the usual percentage is between 50 and 60), and (b) in the size class curve. The broad range of variability in the size-and-sex composition of catches of rock grenadier is characteristic in general of the central portion of the Atlantic and it is due to the vertical migration of this species. Consequently, the example under consideration is not at variance with the existence of intrapopulational heterogeneity and only indicates that different groupings had turned up in the catches or that their ratio had changed. This is clearly due to the imbalance of many of the samples examined due to the deficit of heterozygotes and

the significant changes in local genetypic frequencies that we twice noted.

Thus, each local population of rock grenadier can be regarded as a system of structural units that differ in gene frequencies. Their basis is clearly individual generations, which puts them in a single category with elementary populations as interpreted by N. V. Lebedev [1967]. The lengthiness of the rock grenadier's spawning period, the ability of males to fertilize eggs over the greater part of the year, and the multi-age structure of spawning groups [Grigor'ev, 1972] indicate the non-hereditary character of the varibility that is observed. At the same time, the existence of genotypic and gene /36
frequencies of locus Est-1 over the greater part of the rock grenadier's geographic range provides a basis for assuming that local groupings of this species, as well as their structural components, are part of a stable population system similar to that described earlier by Yu. P. Altukhov and Yu. G. Rychkov [1970]. The results that were obtained from studying the variability of sorbitoldehydrogenase and nicotinamide-adenine dinucleotide phosphate (NAD), dependent on malatedehydrogenase in the grenadier, also confirm this conclusion.

The mechanism by which the age variability of gene frequencies appears and persists on individual banks is evidently due to the existence of quasi-stationary vortical formations in regions inhabited by the grenadier, which were previously considered to be zones of enhanced biological productivity [Darnitskii and Boldyrev, 1979]. By partially preventing the transfer of grenadier eggs and larvae beyond the limits of the submarine upland, these gyrals condition their developmental environment and, when unfavorable factors come into being

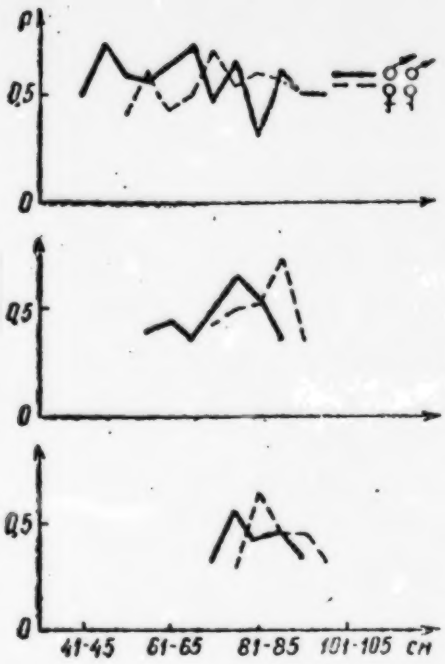

Figure 1: Variations in the frequency of gene Est-1 B in rock grenadier samples as a function of the sex and the size of the fish.

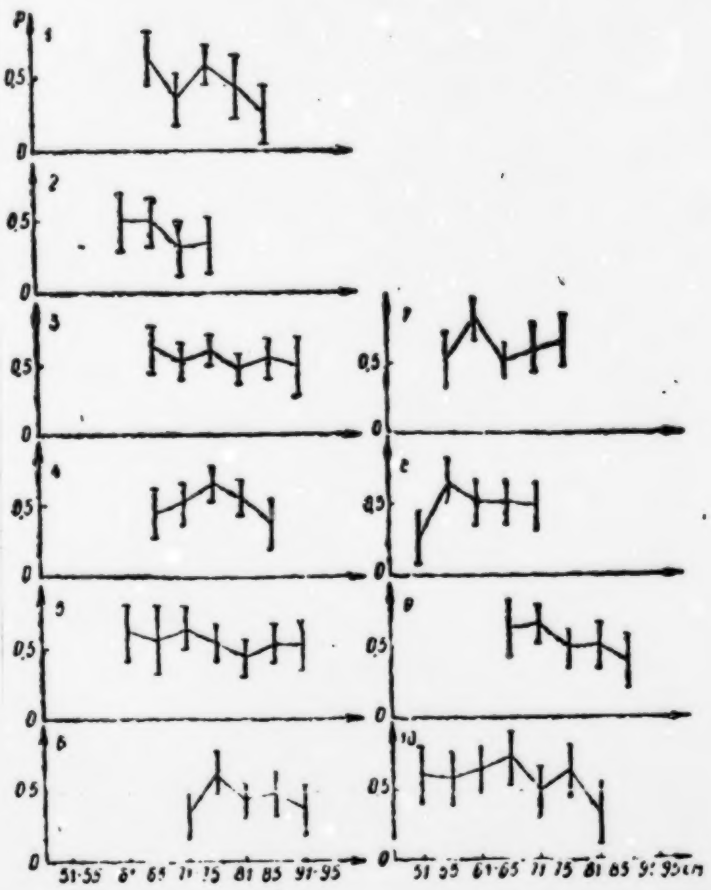

Figure 2: Variations in the frequency of gene Est-1 B in rock grenadier males as a function of size. Samples 1 to 6 are from the Central region, 7 and 8 are from the Northwestern Atlantic, and 9 and 10 from the Northeastern Atlantic. The vertical lines indicate the 95% confidence limits.

outside the range of the population's adaptational optimum, generations can appear with mixed gene frequencies. This is all the more likely since certain stages in grenadier development can occur in the upper, and most variable layers of the ocean [Merrett, 1978].

It is at just this period in the life cycle, it would seem, that the exchange of individuals between different local populations takes place, and during which the distance that eggs and larvae can be carried may depend on their location relative to the thermocline and the specific features of the circulation of water bodies in the given region [Marshall, 1955]. /37

CONCLUSION

In conclusion, the rock grenadier of the North Atlantic exhibits a number of hierarchically interlinked population structures, in the simplest of which the dominant process is that of genetic differentiation; in the more complex structures it is that of integration.

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SUMMARY

The analysis of the distribution of gene frequences at the locus Est-1 in blantnose rattail has indicated a number of hierarchically-adjacent population structures, in the most primitive of which genetic differentiation processes are predominant whereas in more complicated structures integration processes prevail. It is likely that the former are linked with a selective mortality occurring at early stages of development of the species and the last is related to transport of eggs and larvae of the species by oceanic currents.